GSFC MO&DSD TECHNOLOGY DEVELOPMENT PLAN

TITLE: ADVANCED SPACE SYSTEMS FOR USERS	
NASA UPN: 315-90-18	WORK AREA MANAGER: Michael Powers
EFFECTIVE DATE: 1 October 1996	ADDRESS: Code 737.2 Goddard Space Flight Center Greebelt, Maryland 20771
RELATED UPNs:: 224-40-32-01, 224-40-32-02	PHONE: (301) 286-4820
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BRIEF TECHNICAL SUMMARY *(Objectives and Approach)*

The goal of this technology area is to provide improved space communications performance, commensurate with lower cost, to support NASA science missions into the 21st century. To achieve this goal, technology will be developed that will enable these missions, primarily a new generation of small SMEX class satellites, to communicate through the Tracking and Data Relay Satellite System (TDRSS) and ground networks with hardware that is compact, light weight, power efficient, and low cost. The specific technical scope of this program encompasses all elements of the spacecraft communications system, including RF systems such as antennas and transponders, as well as telecommunications channel coding methods and data compression. Technology is developed recognizing the need to mitigate overall mission cost, which includes not only the cost of space hardware, but also that of ground equipment, science data processing and delivery and day-to-day mission operations. Although initiated for the small satellite user, the technology resulting from this program is intended to be useful for the entire range of NASA space flight missions as well.

APPROVALS		
WORK AREA MANAGER:	DIVISION MANAGER:	GSFC PROGRAM MANAGER:

JUSTIFICATION AND BENEFITS

The tasks associated with this technology area help ensure the readiness of space communications and tracking for future missions by evaluating and predicting the advances in electronics, communications, microprocessors, and software that are occurring in both the public and private sectors; by fostering and leading the development of other technologies required to meet NASA-unique system requirements; and by developing the expertise within NASA to apply these technologies to meet future space goals. For example, the military has long been involved in the development of high performance phased array technology that meets some very demanding requirements in terms of rapid beam steering and interference nulling. This technology is being evaluated and subsets of the technology used to develop low cost solutions for phased array antenna systems that are best suited to NASA requirements for future small satellite missions.

APPROACH AND PLAN

RF and Antenna Systems (315-90-18-01)

FY97 activities include:

(1) Coordination of Ka-band and Ku-band antenna development activities with related S-band transponder activities that are ongoing in other development programs.

(2.) Planning for an ultimate transition of Ku-band capability to Ka-band in order to use the next generation of TDRS spacecraft. As a part of this planning, a ground station was assembled at the GSFC Radio Frequency Simulated Operations Center (RFSOC) to collect Ka-band channel error statistics for wide bandwidth communications channels through the Advanced Communications Technology Satellite (ACTS). These data collected in FY96 will be analyzed and used in the design and verification of channel coding techniques for future operational links in the Ka-band. A byproduct of this effort will be a Ka-band infrastructure which will be available to support future developmental and operational projects using that band.

(3.) Completion of a Ku-band medium gain phased array to meet the required science data return capability for small satellites through the Space Network. The state-of-the-art in electronically steered, phased array technology was investigated previously. Technical and operational merits of a phased array, including body-fixed operation, power consumption, size, and weight, were analyzed in comparison with those of a conventional antenna, gimbals and deployable boom arrangement. An investigation of performance trade-offs was conducted that included quantization error, element clustering, scan angle, array gain, packaging issues, and cost. An architecture that could be realized using GSFC in-house facilities and processes, as well as contractor supplied components, was completed and implementation begun. Requirements for ferrite phase shifters were determined. The phased array antenna subsystem includes the distribution network, radiating elements, board interconnects, driver elements, power conditioner, and controller card. Models of the in-house portions of the array were fabricated in FY96 and will continue to be tested early in FY97. A contractor will fabricate, test, and deliver the phase shifters for integration into the final package. Finally, an engineering model will be completed during FY97.

Structured Information Data Systems (315-90-18-02)

Information data system technology will be developed to support increased scientific data return from space within telecommunications channels constrained by bandwidth and Effective Isotropic Radiated Power (EIRP). This task will include development of a High-Performance Data Compression (HPDC) chip set based on a Discrete Cosine Transform (DCT) that can operate at 10 Mbps with selectable compression rates of up to 20 to 1, while providing excellent quality.

4th Generation TDRSS User Transponders (224-40-32-01)

The objective of this effort is to develop a fourth generation replacement for the NASA standard TDRSS user transponder. This development will advance technologies that will facilitate access to TDRSS by small spacecraft such as the SMEX and the MIDEX missions. Critical elements being addressed are the receiver DC power consumption, volume, weight, and cost. It will also address the science data return through TDRSS by providing a Ku-band transmitter output with very little impact to the spacecraft. Motorola, Inc. and Cincinnati Electronics, Inc. were each awarded contracts in September, 1996, to produce one engineering model, one protoflight unit, and up to five optional flight units.

The work being performed under this effort is an ongoing program that began under Code O sponsorship and is being continued by SOMO.

The transponder maintains the same major TDRSS and Ground Network (GN) capabilities as the second and third generation transponders. Physical improvements include the reduction of DC power consumption in the receive mode to 6 watts, reduction of DC power in the S-band transmit mode to 34 watts, reduction of the footprint to 9 x 8 x 5 inches, and reducing the weight to 8 pounds. Interfaces will be improved by using standard MIL-STD-1773 and RS-422 interfaces. Performance improvements include increasing the command data rates to 10 kbps, increasing the GN transmit data rate to at least 3 Mbps, and providing a TDRSS Ku-band exciter that will interface with an external power amplifier. A restructured performance assurance program is being used which places more emphasis on testing than on analysis, and more leeway in the selection of parts, as long as overall reliability is maintained.

Ka-band Phased Array Antenna Development (224-40-32-02)

The objective of this project is to develop an antenna subsystem to support the future requirements of users of NASA space communication networks. In the past, the Space Network has been primarily used by larger spacecraft which can accommodate the size and mass of a large aperture gimbaled antenna. By moving to Ka-band, the size of the aperture can be reduced, while still maintaining adequate gain to transmit high rate science data through TDRSS. Electrically steered phased array technology is the ideal technology for the small satellite missions due to its technical and operational merits (see item 3, Ku-band activity). Ka-band has been selected for this development due to its compatibility with the TDRS H, I, J and follow-on spacecraft and the long term viability and primary nature of the international frequency allocation. The Ka-band allocation also has the significant advantage of allowing direct Low Earth Orbit (LEO) to Earth data returns (currently in a secondary status), instead of using the TDRSS. This option increases network user flexibility in data return options, and broadens the potential user base for the technology.

This effort was initiated by Code O and will be accomplished by a fully competitive procurement activity. This activity will result in the delivery of an engineering model, a protoflight model, and up to four space flight qualified phased arrays. The approach for the procurement activity is to allow offerors to propose their most appropriate technology for this system, which may take the form of either a “passive” (electronically steered antenna with a single SSPA), or an “active” (electronically steered antenna with small amplifiers at each antenna element) array. Activities in FY97 include contract negotiations and award by March and a Preliminary Design Review in September.

DELIVERABLES

ITEM	DATE
RF and Antenna Systems (315-90-18-01)	
a. ACTS experiment test results	12/96
b. Demonstrate Ku-band antenna fixed beam subarray	10/96
c. Integrate phase shifters into Ku-band antenna array	4/97
d. Test Ku-band array in anechoic chamber	7/97
e. Test Ku-band array via Space Network from GSFC	9/97
Structured Information Data Systems (315-90-18-02)	
a. Complete HPDC EDCT ASIC design	06/97
b. Complete design and fabricate USDA IC	07/97
c. Evaluate HPDC performance of SSTI/Lewis Hyper Spectral Imager data	09/97
d. Initiate design of quantizer ASIC	08/97
4th Generation TDRSS User Transponders (224-40-32-01)	
a. TDRSS transponder Preliminary Design Reviews (PDRs)	3/97
b. TDRSS transponder Critical Design Reviews (CDRs)	FY98
c. Delivery ofTDRSS transponder engineering model	FY98
d. Delivery ofTDRSS transponder protoflight model	FY99

ITEM	DATE
Ka-band Phased Array Antenna Development (224-40-32-02)	
a. Ka-band antenna contract begins	3/97
b. Ka-band antenna Preliminary Design Review	9/97
c. Ka-band antenna Critical Design Review	FY98
d. Delivery of Ka-band antenna engineering model	FY98
e. Delivery of Ka-band antenna protoflight model	FY99
f. Optional Ka-band antenna flight units	FY99

RESOURCE REQUIREMENTS

Task Name	**NASA UPN**	**FY97** *($K)*	**FY98** *($K)*	**FY99** *($K)*	**FY00** *($K)*	**FY01** *($K)*	**FY02** *($K)*
RF and Antenna Systems (ACTS Exp., Ku-band Array)	(315-90-18-01)	145	200	200	200	200	200
Structured Information Data Systems	(315-90-18-02)	145	200	200	200	200	200
TDRSS Transponder	(224-40-32-01)						
Ka-band Antenna	(224-40-32-02)						

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SCHEDULE

ADVANCED SPACE SYSTEMS FOR USERS	FY97				FY98		FY99	FY00	FY01	FY02
	Q1	Q2	Q3	Q4	Q1/2	Q3/4				
RF and Antenna Systems (315-90-18-01):										
a. ACTS experiment test results										
b. Demonstrate fixed beam subarray										
c. Integrate phase shifters into array										
d. Test array in anechoic chamber										
e. Test array via Space Network from GSFC										
Structured Information Data Systems (315-90-18-02):										
a. Complete HPDC EDCT ASIC design										
b. Complete design and fabricate USDA IC										
c. Evaluate HPDC performance of SSTI/ Lewis Hyper Spectral Imager data										
d. Initiate design of quantizer ASIC										
Resources by FY ($K):	290				400		400	400	400	400

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SCHEDULE

ADVANCED SPACE SYSTEMS FOR USERS	FY97				FY98		FY99	FY00	FY01	FY02
	Q1	Q2	Q3	Q4	Q1/2	Q3/4				
TDRSS User Transponder (224-40-32-01):										
a. TDRSS transponder PDRs										
b. TDRSS transponder CDRs										
c. Delivery of engineering model										
d. Delivery of protoflight model										
Ka-band Antenna (224-40-32-02):										
a. Ka-band antenna contract begins										
b. Ka-band antenna PDR										
c. Ka-band antenna CDR										
d. Delivery of engineering model										
e. Delivery of protoflight model										
f. Optional Ka-band antenna flight units										
Resources by FY ($K):										